Technology Planning for Future Mars Missions

Samad Hayati
Manager, Mars Technology Program
Mars Program Office, JPL
California Institute of Technology

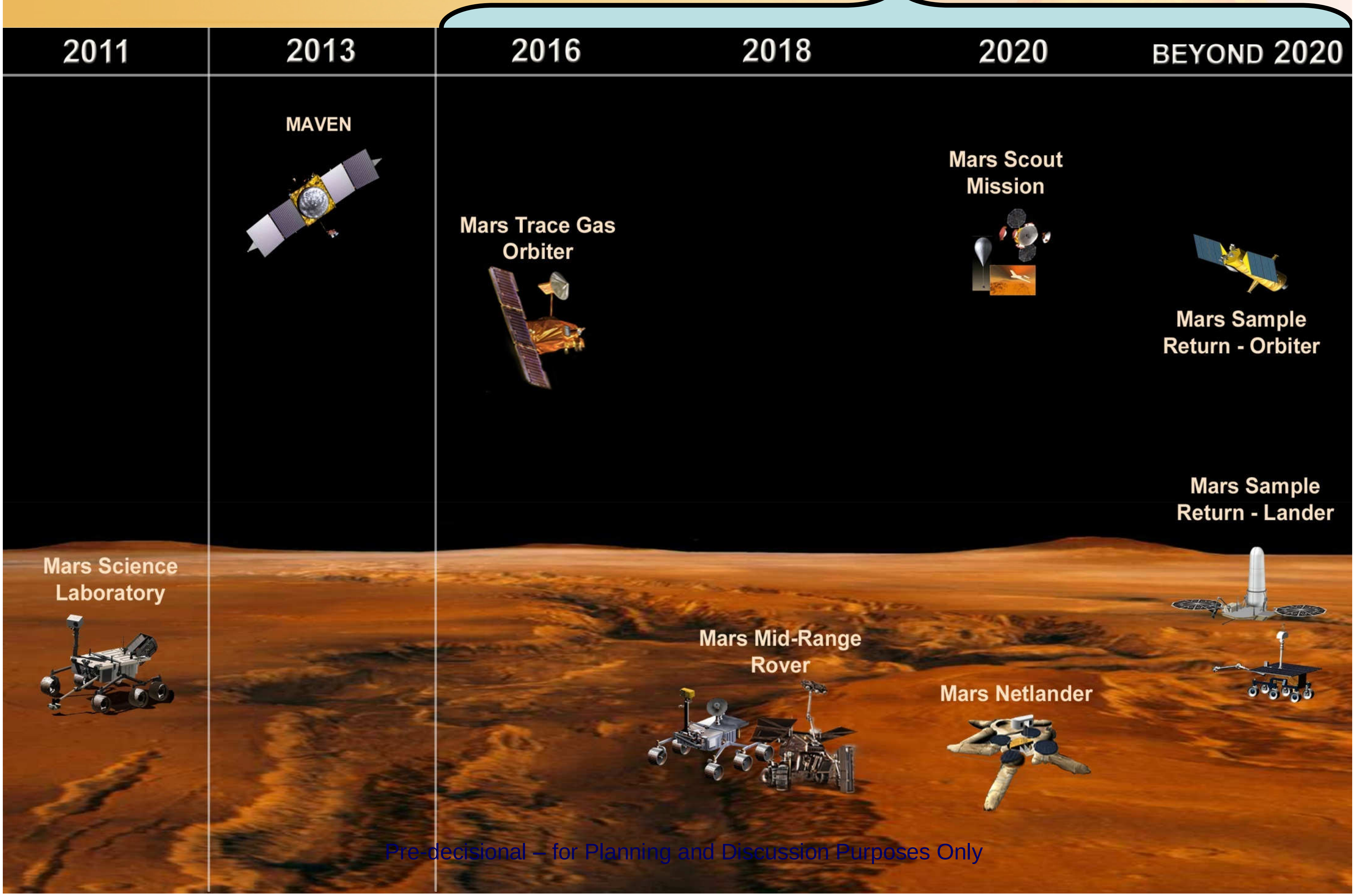
MEPAG, Brown University
Providence, RI

July 29-30, 2009

Outline

- *Candidate future missions*
- *Technologies for future missions*
- *Maturity and priority of identified technologies*
- *Schedule*

Future Missions Considered

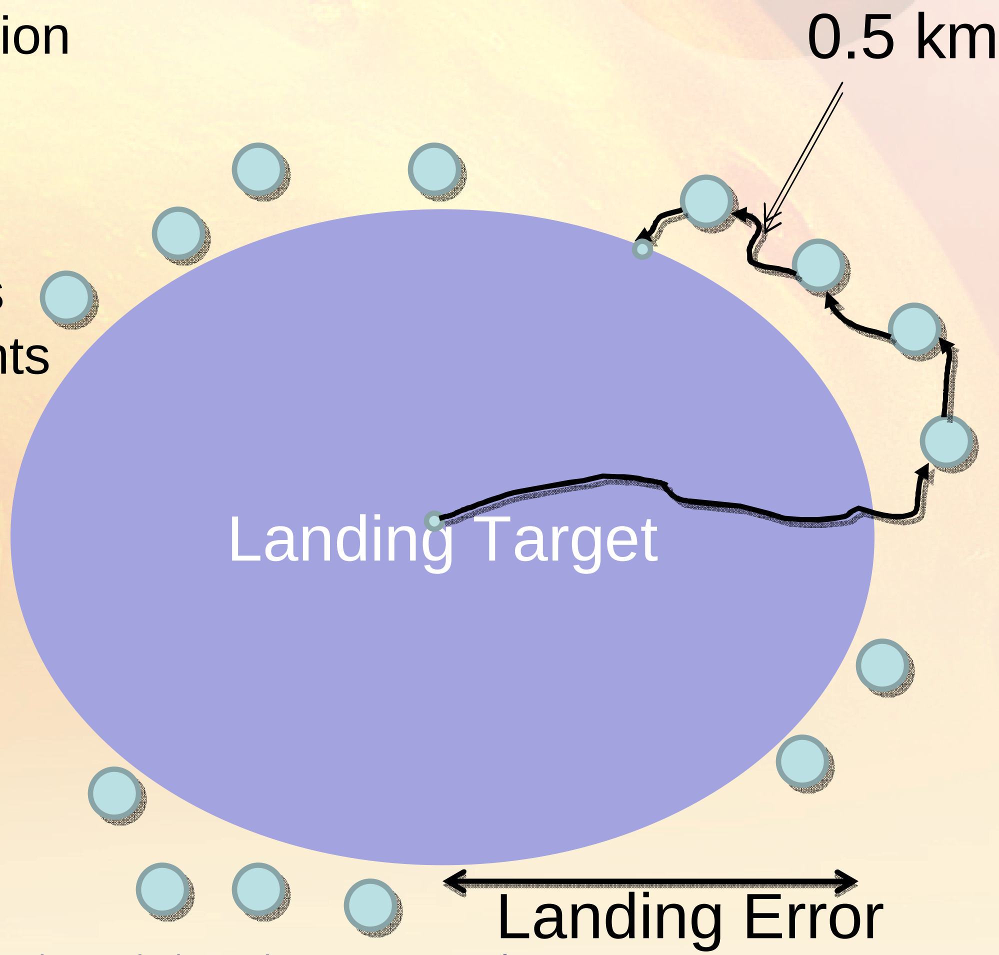


Candidate Future Mission Concepts

- *2016 Trace Gas Orbiter Mission*
- <u>*2018 or 2020 Mid-Range Rover Mission*</u>
- *2018 or 2020 Net Lander Mission*
- <u>*2022+ Mars Sample Return Mission*</u>

Mid-Ranger Rover Mission Concept

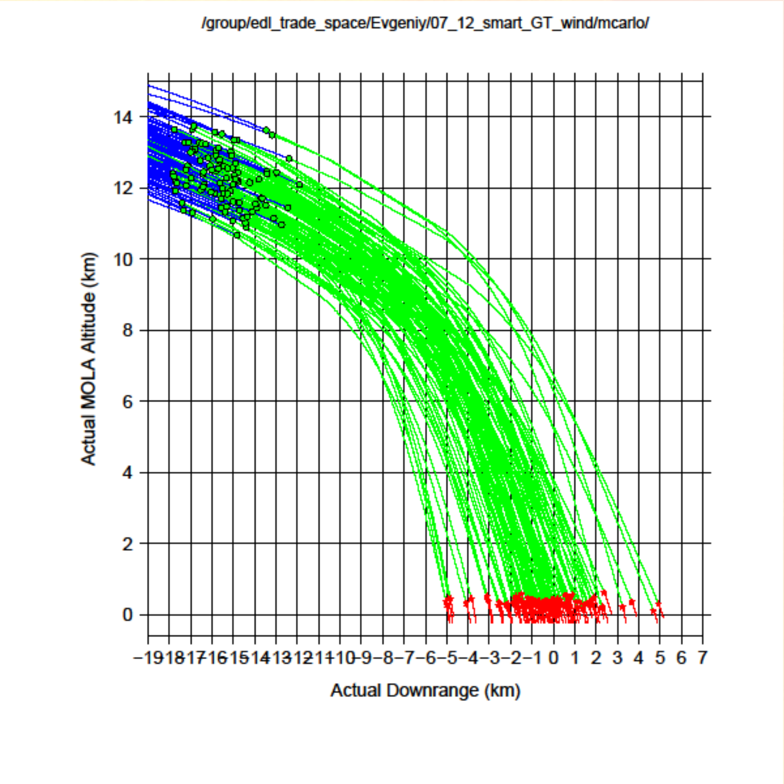
1. **In-situ exploration**
2. **Cache samples for a future mission to return to earth**
   - Obtain 5 cores from each region
   - Total of 20 samples
   - Encapsulate samples
   - Store samples in a canister
   - Avoid contaminating samples from Earth based contaminants



MRR Mission Concept Technologies: Precision Landing

Precision Landing:

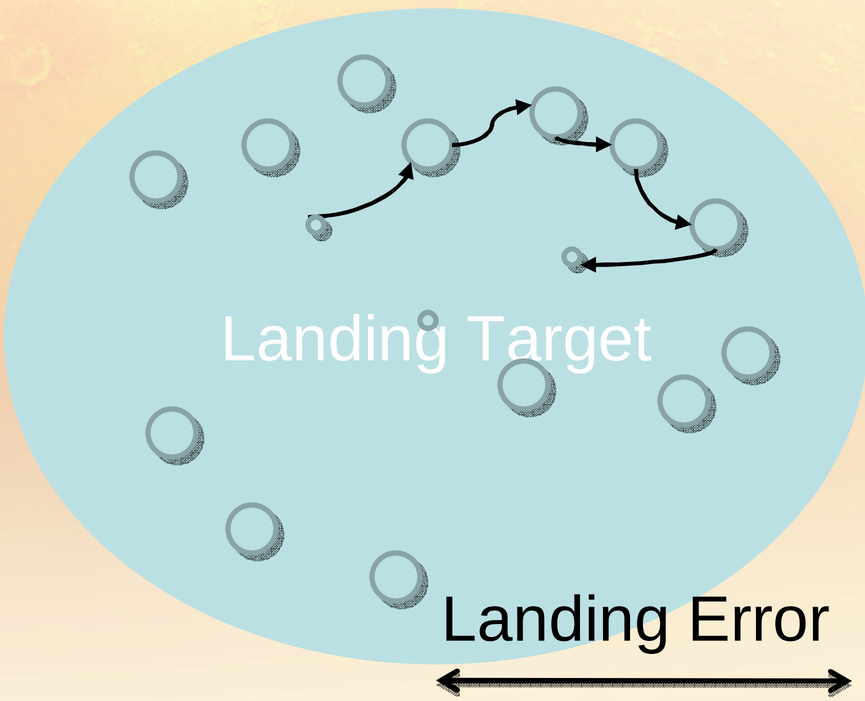
- *Many error sources contribute to the landing error*
- *Guided entry on MSL utilizes its onboard IMU and flies the S/C to zero out known deviations from the target*
- ***Major contributors to the remaining error are***
  - ***IMU initialization error***
  - ***Drift due to winds during parachute phase of descent***
- *Current best estimate is that the landing error could be reduced to ~7km.*
- *Advantage of this technique is that additional fuel would not required to reduce errors*
- *Technology development would consist of accurate modeling and simulation taking into consideration realistic conditions to validate this concept*
- *If MRR carries an upward looking LIDAR to measure winds, MSR lander may be able to use that information to increase its landing precision*



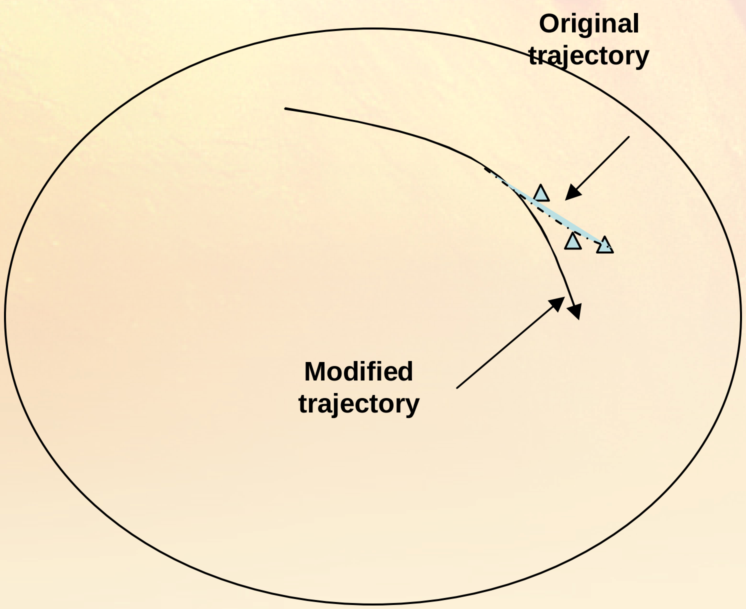
MRR Mission Concept Technologies: Hazard Avoidance

Hazard Avoidance:

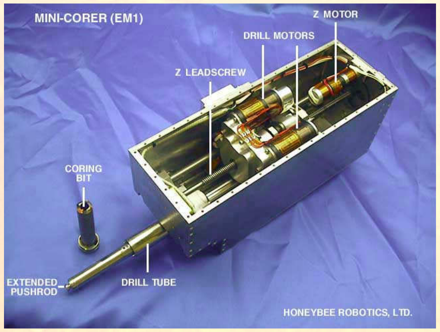
- *If hazard avoidance is utilized, science targets might be selected within landing error ellipse*
- *Technology :*
  - *Terrain Relative Navigation (TRN) could be utilized to image the terrain and use onboard maps to determine the actual position of S/C*
  - *Optimal descent guidance could be used to divert S/C to a safe landing location*



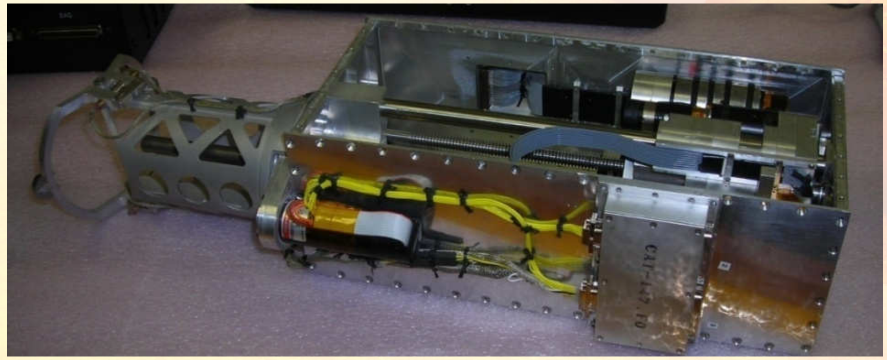
Hazard Avoidance



MRR Mission Concept Technologies: *Sample Acquisition, Encapsulation, and Handling*



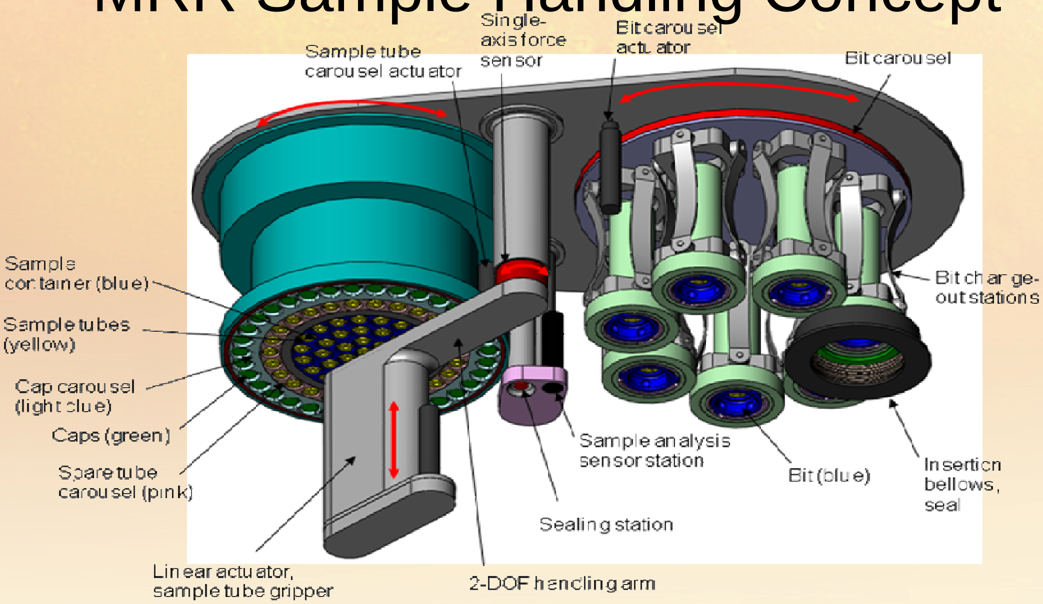
Mini Corer



CAT Designed for MSL

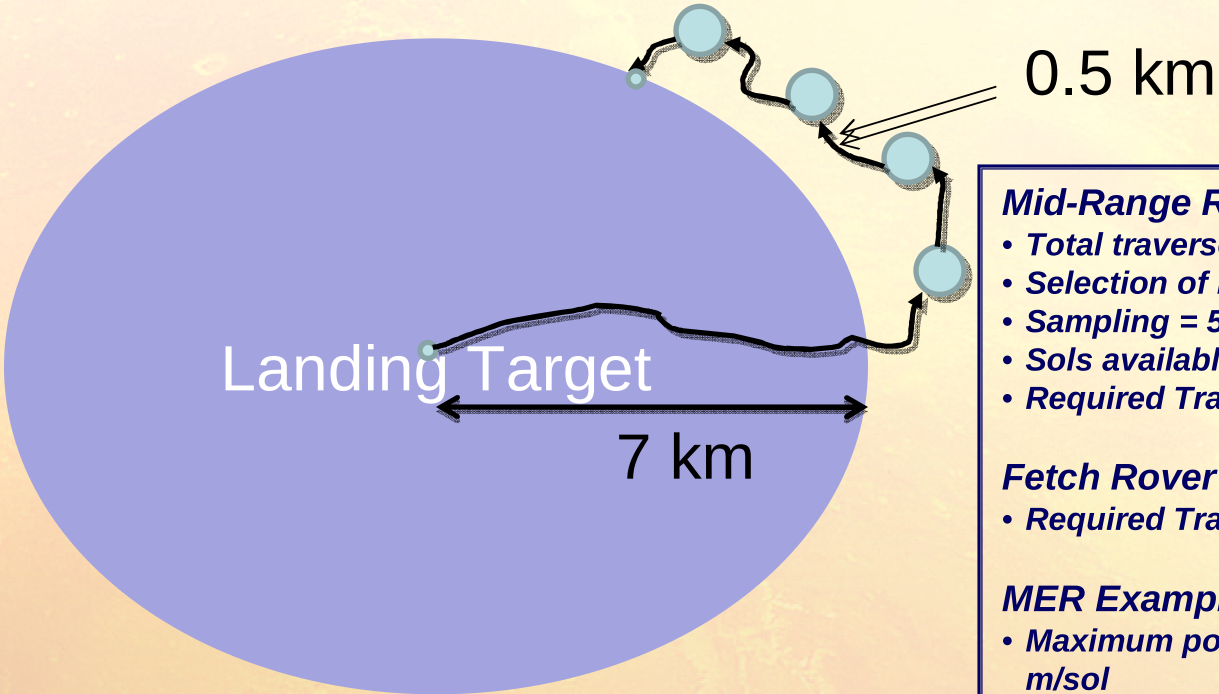
Honeybee Robotics

MRR Sample Handling Concept



- *Coring: 1cmX 5, at least 20 cores*
- *Low-mass, low-power drill*
- *Dry drilling*
- *Coring initialization*
- *Core break-off*
- *Core retention*
- *Core encapsulation*
- *Core storage*
- *Contamination prevention*

MRR Mission Concept Technologies: Rover Technologies



Mid-Range Rover Concept:

- ***Total traverse: 7+5x0.5+0.5= ~10 km***
- ***Selection of regions for sampling 10sols/region***
- ***Sampling = 5sols/sampleX20= 100 sols***
- ***Sols available for traverse: (355-140)x0.7= 150 sols***
- ***Required Traverse speed = 10000/140= 67 m/sol***

Fetch Rover Concept:

- ***Required Traverse speed =12000/150=80 m/sol***

MER Example:

- ***Maximum possible (mechanical and power)= 252 m/sol***
- ***Maximum possible with VO and Auto nav= 29 m/sol***
- ***Need roughly a three-fold improvement in rover speed***

Technology Approach:

•Increase rover drive distances and average speed, by eliminating the need for rovers to stop while performing autonomous navigation and visual odometry.

•Implement FPGA based stereo and visual odometry and improved Autonav

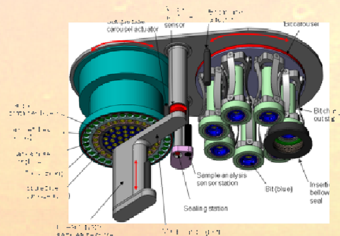
MRR Mission Concept Technologies: Planetary Protection (Round Trip Contamination)

Two approaches might be available:

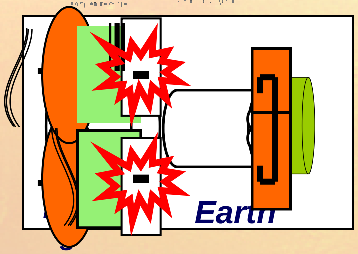
1. ***Dry Heat Microbial Reduction (DHMR) terminal sterilization***
   - *Consists of heating the entire S/C to 112^0 C for 30 hours*
   - *Technology challenges are:*
     - *Hardware compatibility*
     - *Chamber design large enough to accommodate S/C*
     - *Full system bio-barrier to avoid recontamination*
2. ***Component and Subsystem Sterilization***
   - *Component level sterilization of relevant subsystems by DHMR or other methods such as hydrogen peroxide or irradiation*
   - *Clean-assembly strategy to avoid recontamination*
   - *Bio-barriers*
   - *Analytical tools to accurately estimate contamination risks post landing to satisfy probabilistic requirements*

Technologies for Mars Sample Return Mission Concept

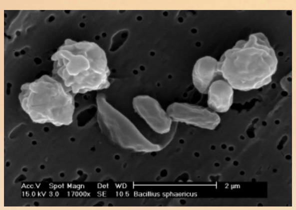
Rover Technology:
- *Increase rover speed for traversing long distance*
- *Rover avionics for low-mass low, low-power fetch rover*



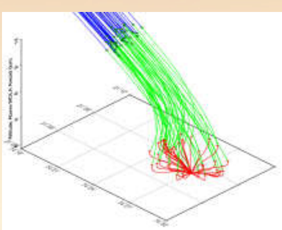
Sample Acquisition, Transfer, and Encapsulation: *Would require coring from a small rover, automated tool change out, and encapsulation capabilities*



Back Planetary Protection: *Meet the goal of less than10^{-6} probability of inadvertent release of a single Mars particle > 0.2 micron in the Earth's biosphere*

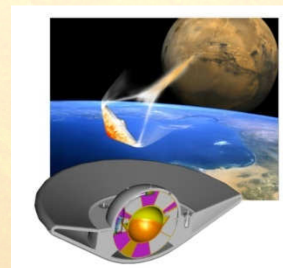


Round-Trip PP: *Full system microbial reduction methods to prevent Mars sample contamination*

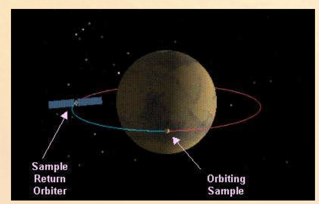


Precision and Safe Landing: *Reduce landing error to ~6-7 km and develop hazard avoidance capabilities for proposed MSR lander*

Mars Ascent Vehicle (MAV): *Develop a <300kg ascent vehicle to lift a 5kg sample container (0.5 kg samples) to a 500 km Mars orbit*



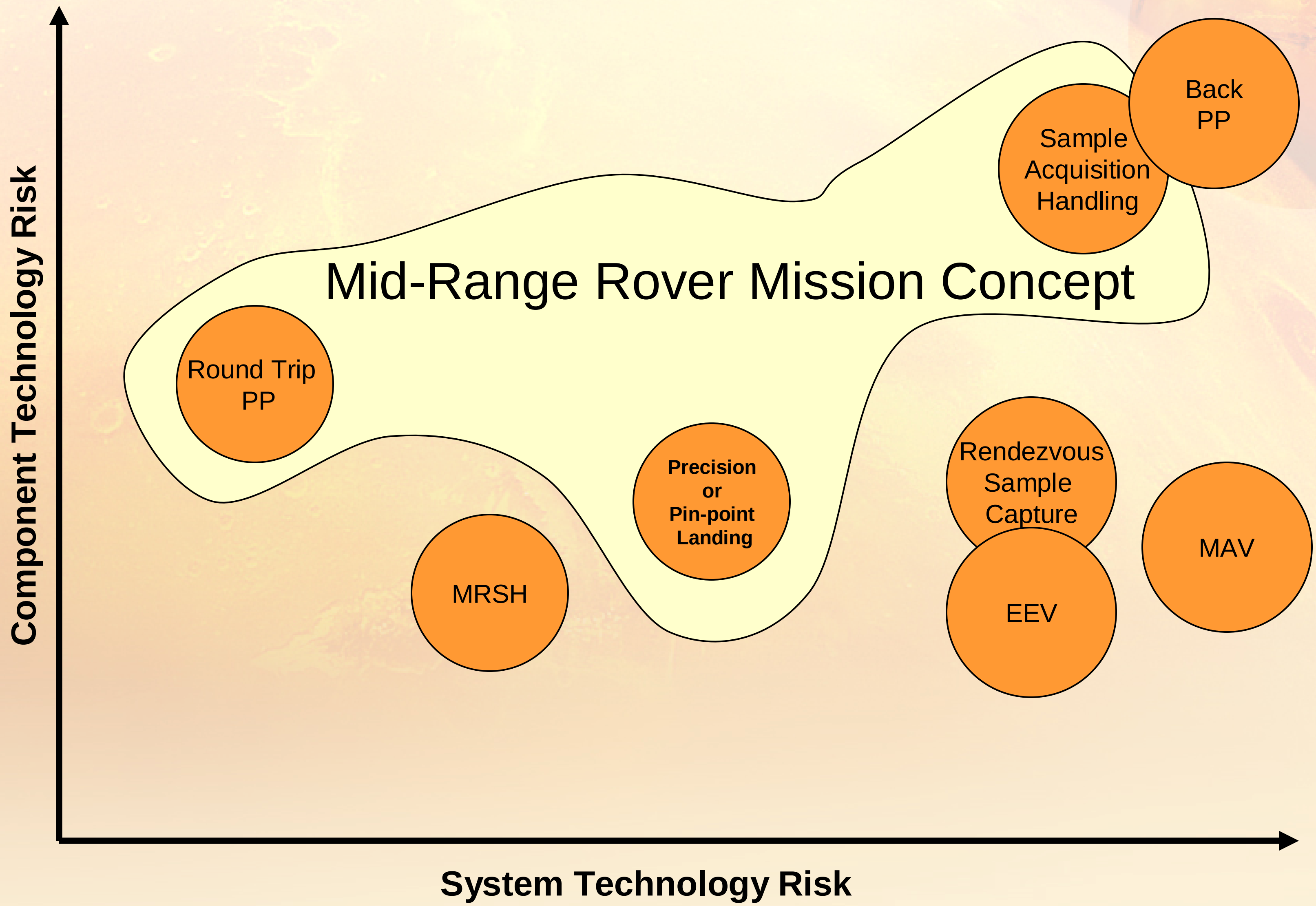
Earth Entry Vehicle: *Develop an Earth Return Vehicle to safely deliver Martian samples to Earth. Satisfy stringent back planetary requirements*



Rendezvous and Sample Capture: *Develop capabilities to track, rendezvous, and capture a small (16cm diameter) Orbiting Sample in Mars orbit autonomously*

Mars Returned Ground Sample Handling: *Develop capabilities to safely handle Martian samples; Avoid contaminating samples and assure containment*

Technology Risks



Example Schedule